CLAIMS

1. Plasma doping apparatus comprising:

a plasma doping chamber;

a platen located in said plasma doping chamber for supporting a workpiece;

an anode spaced from said platen in said plasma doping chamber;

a process gas source coupled to said plasma doping chamber, wherein a plasma containing ions of the process gas is produced in a plasma discharge region between said anode and said platen;

a pulse source for applying pulses between said platen and said anode for accelerating ions from the plasma into the workpiece; and

a mechanism for rotating the workpiece.

2. Plasma doping apparatus as defined in claim 1, wherein said platen is configured for supporting a semiconductor wafer and wherein said mechanism is configured for rotating said platen such that the semiconductor wafer rotates about its center.

3. Plasma doping apparatus as defined in claim 1, wherein said pulse source has a pulse rate that is much greater than a rotation speed of the workpiece.

4. Plasma doping apparatus as defined in claim 1, wherein said mechanism is configured for rotating the workpiece at a speed in a range of about 10 to 600 rpm.

5. Plasma doping apparatus comprising;

a plasma doping chamber containing a platen for supporting a workpiece;

a plasma source for generating a plasma in the plasma doping chamber and for accelerating ions from the plasma into the workpiece; and

a drive mechanism for rotating the workpiece.

6. A method for plasma doping, comprising the steps of:

supporting a workpiece on a platen in a plasma doping chamber;

generating a plasma and accelerating ions from the plasma into the workpiece; and

rotating the workpiece.

7. A method as defined in claim 6, wherein the workpiece comprises a semiconductor wafer and wherein the step of rotating the workpiece comprises rotating the platen such that the semiconductor wafer rotates about its center.

8. A method as defined in claim 6, further comprising the step of applying pulses having a pulse rate between the platen and an anode in the plasma doping chamber, wherein the pulse rate is much greater than a rotation rate of the workpiece.

9. A method as defined in claim 6, wherein the workpiece is rotated at a speed in the range of about 10 to 600 rpm.

~~10~~. Plasma doping apparatus comprising:

a plasma doping chamber;

a platen in said plasma doping chamber for supporting a workpiece;

an anode spaced from said platen in said plasma doping chamber, said anode having a spacing from said platen that varies over the area of said anode;

a process gas source coupled to said plasma doping chamber, wherein a plasma containing ions of the process gas is produced in a plasma discharge region between said anode and said platen; and

a pulse source for applying pulses between said platen and said anode for accelerating ions from the plasma into the workpiece.

11. Plasma doping apparatus as defined in claim 10, wherein said anode comprises two or more anode elements and actuators for individually adjusting the spacing between respective anode elements and the platen to produce a desired dose uniformity in the workpiece.

12. Plasma doping apparatus as defined in claim 11, wherein said two or more anode elements comprise annular rings.

13. Plasma doping apparatus as defined in claim 10, wherein the workpiece comprises a semiconductor wafer and wherein the spacing between said anode and said platen is adjustable as a function of radius relative to the center of the semiconductor wafer.

14. Plasma doping apparatus comprising:

a plasma doping chamber containing a platen for supporting a workpiece;

an anode spaced from said platen in said plasma doping chamber, said anode comprising two or more anode elements and actuators for individually adjusting the spacing between said two or more anode elements and the platen;

a process gas source coupled to said plasma doping chamber, wherein a plasma containing ions of the process gas is produced in a plasma discharge region between said anode and said platen; and

a pulse source for applying pulses between said platen and said anode for accelerating ions from the plasma into the workpiece.

15. A method for plasma doping, comprising the steps of:

supporting a workpiece on a platen in a plasma doping chamber;

positioning an anode in the plasma doping chamber in spaced relationship to the platen, said anode having two or more anode elements;

adjusting the spacing between one or more of said anode elements and the platen; and

generating a plasma between the anode and the platen and accelerating ions from the plasma into the workpiece.

16. A method as defined in claim 15, wherein the workpiece comprises a semiconductor wafer and wherein the step of adjusting the spacing comprises adjusting the spacing of said anode elements as a function of radius relative to the center of the semiconductor wafer.

17. A method as defined in claim 15, wherein the anode elements comprise annular rings and wherein the step of adjusting the spacing comprises adjusting the spacing between one or more of the annular rings and the platen.

18. Plasma doping apparatus comprising:

a plasma doping chamber having a cylindrical geometry;

a platen in said plasma doping chamber for supporting a workpiece;

an anode spaced from said platen in said plasma doping chamber;

a process gas source coupled to said plasma doping chamber, wherein a plasma containing ions of the process gas is produced in a plasma discharge region between said anode and said platen;

a pulse source for applying pulses between said platen and said anode for accelerating ions from the plasma into the workpiece; and

a plurality of magnetic elements disposed around the plasma discharge region for controlling the radial density distribution of the plasma in the plasma discharge region to thereby control the dose uniformity of the ions implanted into the workpiece.

19. Plasma doping apparatus as defined in claim 18, wherein said magnetic elements are disposed on or near said anode.

20. Plasma doping apparatus as defined in claim 19, wherein said magnetic elements are arranged in one or more annular rings.

21. Plasma doping apparatus as defined in claim 19, wherein said magnetic elements are radially aligned to form a spoke configuration.

22. Plasma doping apparatus as defined in claim 18, wherein said magnetic elements have alternating polarities facing the plasma discharge region.

23. Plasma doping apparatus as defined in claim 18, wherein said magnetic elements are configured to increase the plasma density in an outer portion of the plasma discharge region.

24. Plasma doping apparatus as defined in claim 18, wherein said magnetic elements are arranged in a cylindrical array around the plasma discharge region.

25. Plasma doping apparatus as defined in claim 24, wherein said magnetic elements comprise axial magnetic elements having alternating polarities facing the plasma discharge region.

26. Plasma doping apparatus as defined in claim 18, further comprising a hollow electrode surrounding the plasma discharge region, wherein said magnetic elements are disposed on or near said hollow electrode.

27. Plasma doping apparatus as defined in claim 18, wherein said magnetic elements produce cusp magnetic fields in a region adjacent to the plasma discharge region.

28. A method for plasma doping, comprising the steps of:

supporting a workpiece on a platen in a plasma doping chamber;

generating a plasma in the plasma doping chamber and accelerating ions from the plasma into the workpiece; and

magnetically controlling the radial density distribution of the plasma to thereby control the dose uniformity of the ions implanted into the workpiece.

29. A method as defined in claim 28, wherein the step of magnetically controlling the radial density distribution of the plasma comprises controlling the radial density distribution with magnetic elements that produce a prescribed radial magnetic field profile

30. A method as defined in claim 28, wherein the step of magnetically controlling the radial density distribution of the plasma comprises controlling the radial density distribution with one or more annular rings of magnetic elements disposed adjacent to the plasma.

31. A method as defined in claim 28, wherein the step of magnetically controlling the radial density distribution of the plasma comprises controlling the radial density distribution with radially aligned magnetic elements which form a spoke configuration.

32. A method as defined in claim 28, wherein the step of magnetically controlling the radial density distribution of the plasma comprises increasing the plasma density in an outer portion of the plasma doping chamber.

33. A method as defined in claim 28, wherein the step of magnetically controlling the radial density distribution of the plasma comprises increasing the plasma density in a specified portion of the plasma doping chamber by providing magnetic fields adjacent to the specified portion of the plasma doping chamber.